## REMARKS

With entry of this Amendment, claims 1-30 are pending. Claims 1, 8, 10, 13, 22, 27, 29 and 30 are amended, leaving claims 2-7, 9, 11, 12, 14-21, 23-26 and 28 unchanged.

In view of the arguments below, the Applicant respectfully requests allowance of claims 1-30.

IN THE SPECIFICATION

The Applicant has amended the paragraph beginning on page 4, line 16 and the paragraph beginning on page 7, line 21 to correct minor editorial errors. The Applicant hereby requests entry of these amendments.

IN THE CLAIMS

CLAIM REJECTIONS UNDER 35 U.S.C. §102

Claims 1-4 and 22-24 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 3,370,198, issued to Rogers et al. ("Rogers").

Independent claim 1

Amended claim 1 calls for:

A thruster for use with an external power supply, the thruster comprising:
a propellant that exists in a non-gaseous state at standard temperature and pressure, the propellant having a melting point $T_m$, and a boiling point $T_b$;
a plasma comprising ionized propellant vapors;
a reservoir adapted to house the propellant in a non-gaseous state, the reservoir heated by the plasma; and
at least one electrode positioned to intercept a fraction of the plasma to control heat input to the reservoir to maintain the temperature of the propellant between $T_m$ and $T_b$.

Rogers teaches a plasma accelerator 10 having an outer cylindrical electrode 12 which is concentric with and surrounds a terminal end of a first inner electrode 14, and a second inner electrode 16. The material to be ionized and accelerated in the plasma accelerator 10 is stored in chamber 18 in tank 20 prior to its delivery to the area between the first and second inner electrodes 14, 16. Preferably, the material to be accelerated 19 is either cesium or potassium. As shown in Fig. 1, the cesium 19 is heated in chamber 18 by heating elements 22 to a temperature above its melting point. Cesium vapors are directed through a series of conduits to a cylindrical chamber 30 in the elongated tubular portion 29 of the first inner electrode 14, to an area between a terminal end 76 of the first electrode 14 and a terminal end 78 of the second electrode 16. Coolant 41 is delivered to a chamber 42 within inner electrode 16.

In operation, the heating element 22 is energized and the cesium 19 is vaporized within chamber 18. Surface 78 is maintained at a low temperature by the passing of the coolant 41 into chamber 42. A portion of the cesium vapor (at approximately 100° F) comes in contact with the cold tungsten surfaces 76 and 78 and solidifies, or condenses, on both of these surfaces, although the primary deposit is on surface 78. Preferably, when the cesium vapor is in the area adjacent surfaces 76 and 78 and a certain portion of the cesium vapor has been deposited on the tungsten surfaces, the plasma accelerator 10 is ready to be discharged.

Pre-ionization occurs when switch 58 is closed and the energy stored in a first capacitor 56 discharges an electric arc between surfaces 76 and 78. This triggering pulse causes a substantial degree of surface ionization, thermal ionization, and electron impact ionization of the cesium deposited on these two surfaces. The cesium electric arc discharge between surfaces 76 and 78 extends outwardly toward the inner tantalum surface 13 of outer electrode 12. When the gap has been sufficiently closed, the low-inductance and high-energy storage capacitor 50 discharges circumferentially between surface 76 and the inner surface 13 at many points along both surfaces. Preferably, the cesium vapor in chamber 74, and generally adjacent surfaces 76 and 78 and the inner surface 13 of outer electrode 12, is pre-ionized to a large extent by three separate actions prior to the discharge of the main capacitor. First, surface ionization between the cesium and tungsten surfaces 76 and 78, secondly, heating of the cesium vapor by the electric current flowing between surfaces 76 and 78 as the capacitor 56 is discharged, and thirdly, surface ionization at the inner tantalum surface 13. Due to the pre-ionization of the cesium vapor

between the first inner electrode 14 and inner electrode 16, substantially all of the 20,000 volts of the low-inductance, high-energy storage capacitor 50 accelerates the cesium.

Thus, Rogers teaches heating a propellant, namely, cesium in a tank 20 remote from the accelerator 10. The heating elements 22 heat the cesium to a temperature above its melting point. However, Rogers does not teach using the ionized propellant to heat the tank 20. Specifically, Rogers does not teach "a reservoir adapted to house the propellant in a non-gaseous state, the reservoir heated by the plasma," as required in amended claim 1. Furthermore, Rogers does not teach "at least one electrode positioned to intercept a fraction of the plasma to control heat input to the reservoir to maintain the temperature of the propellant between $T_m$ and $T_b$," as further required in amended claim 1.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §102(b) rejection of claim 1.

Dependent claims 2-4

Claims 2-4 are each ultimately dependent upon amended claim 1, and are therefore allowable based upon amended claim 1, and upon other features and elements claimed in claims 2-4 but not discussed herein.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §102(b) rejection of claims 2-4.

Independent claim 22

Amended claim 22 calls for:

A method for producing a thrust in a thruster having an external power supply, the method comprising:

providing a propellant that exists in a non-gaseous state at standard temperature and pressure, the propellant having a melting temperature $T_m$ and a boiling temperature $T_b$;

providing a reservoir to house the propellant in a non-gaseous state;

vaporizing the propellant to form propellant vapors;

ionizing the propellant vapors to form a plasma comprising ionized propellant vapors;

heating the reservoir with the plasma; and

maintaining the temperature of the propellant between $T_m$ and $T_b$ by controlling power input from the external power supply and heat input from the plasma.

Rogers teaches heating cesium 19 in a tank 20 remote from the accelerator 10, feeding the vaporized cesium to the accelerator 10, pre-ionizing the cesium vapors by discharging capacitor 56, and accelerating the ionized cesium vapors by discharging the storage capacitor 50. However, Rogers does not teach using the ionized propellant to heat the tank 20 that is positioned remotely from the accelerator 10. Specifically, Rogers does not teach "heating the reservoir with the plasma," or "maintaining the temperature of the propellant between $T_m$ and $T_b$ by controlling power input from the external power supply and heat input from the plasma," as claimed in amended claim 22.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §102(b) rejection of claim 22.

<u>Dependent claims 23 and 24</u>

Claims 23 and 24 are each ultimately dependent upon amended claim 22, and are therefore allowable based upon amended claim 22, and upon other features and elements claimed in claims 23 and 24 but not discussed herein.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §102(b) rejection of claims 23 and 24.

CLAIM REJECTIONS UNDER 35 U.S.C. §103

Claims 1-4 and 22-24 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Rogers. In addition, claims 1-9, 22-26 and 30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Rogers in view of the AIAA paper to Tverdokhlebov et al. ("Tverdokhlebov"), and under 35 U.S.C. §103(a) as being unpatentable over Tverdokhlebov in view of Rogers.

Independent claim 1

As described above, Rogers teaches heating cesium 19 in a tank 20 remote from the accelerator 10, feeding the vaporized cesium to the accelerator 10, pre-ionizing the cesium vapors by discharging capacitor 56, and accelerating the ionized cesium vapors by discharging the storage capacitor 50. However, Rogers does not teach using the ionized propellant to heat the tank 20, nor is there any suggestion or motivation to do so, because the tank 20 is physically separated from the accelerator 10, and particularly, from the portions of the accelerator 10 that contain ionized cesium vapors.

Thus, Rogers does not teach, describe or suggest "a reservoir adapted to house the propellant in a non-gaseous state, the reservoir heated by the plasma," as required in amended claim 1. Furthermore, Rogers does not teach, describe or suggest "at least one electrode positioned to intercept a fraction of the plasma to control heat input to the reservoir to maintain the temperature of the propellant between $T_m$ and $T_b$," as further required in amended claim 1.

Tverdokhlebov teaches a hall thruster using bismuth as a propellant. Unlike the reservoir claimed in claim 1, the anode 1 shown in Figure 1 of Tverdokhlebov houses vaporized bismuth. Bismuth is melted and vaporized in a reservoir remote from the thruster shown in Figure 1 and a vapor feed system feeds vaporous bismuth to the anode 1. Tverdokhlebov describes a "simple vapor feed system employing resistive heating of a thin-walled molybdenum tube by cutoff current" and describes this scheme as helping "to avoid condensation of evaporated bismuth flow along its all (*sic*) path from reservoir with solid bismuth to the anode of the thruster" (Tverdokhlebov, page 3). Thus, Tverdokhlebov teaches melting and vaporizing bismuth remotely from the thruster.

Tverdokhlebov teaches a first stage power supply and a second stage power supply, such that the anode 1 houses the gaseous propellant. However, the anode 1 is not used to control any thermal properties of the thruster. Rather, the first stage power supply and the second stage power supply are used to separate the electron transfer into two stages. The first stage power supply works to pre-ionize the vaporous bismuth with low voltage, and the second stage power supply functions to accelerate the pre-ionized bismuth at a high voltage. Thus, Tverdokhlebov does not teach heating the reservoir that melts and vaporizes the bismuth with ionized bismuth vapors, nor is there any suggestion, motivation or reasonable expectation of success to do so due to the physical separation between the reservoir and the thruster. As a result, Tverdokhlebov does not teach, describe or suggest a thruster comprising a reservoir "adapted to house the propellant in a non-gaseous state, the reservoir heated by the plasma," as required in amended claim 1. In addition, Tverdokhlebov does not teach, describe or suggest "at least one electrode positioned to intercept a fraction of the plasma to control heat input to the reservoir to maintain the temperature of the propellant between $T_m$ and $T_b$," as required in amended claim 1.

Thus, Rogers and Tverdokhlebov, either alone or in combination, do not teach, describe or suggest all of the claim limitations of amended claim 1.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §103(a) rejection of claim 1.

Dependent claims 2-9

Claims 2-9 are each ultimately dependent upon amended claim 1, and are therefore allowable based upon amended claim 1, and upon other features and elements claimed in claims 2-9 but not discussed herein.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §103(a) rejection of claims 2-9.

Independent claim 22

As discussed above, Rogers does not teach heating the tank 20 with ionized propellant, nor is there any suggestion or motivation to do so, because the tank 20 is physically separated

from the accelerator 10, and particularly, from the portions of the accelerator 10 that contain ionized cesium vapors.

Thus, Rogers does not teach, describe or suggest "heating the reservoir with the plasma," as required in amended claim 22. Furthermore, Rogers does not teach, describe or suggest "maintaining the temperature of the propellant between $T_m$ and $T_b$ by controlling power input from the external power supply and heat input from the plasma," as claimed in amended claim 22.

Tverdokhlebov teaches melting and vaporizing bismuth remotely from the thruster and then maintaining the bismuth in a gaseous form from the remote position to the thruster. Tverdokhlebov further teaches a first stage power supply and a second stage power supply. The anode 1 of the thruster taught by Tverdokhlebov is not used to control any thermal properties of the thruster. Rather, the first stage power supply and the second stage power supply are used to separate the electron transfer into two stages. Thus, Tverdokhlebov does not teach heating the reservoir that melts and vaporizes the bismuth with ionized bismuth vapors, nor is there any suggestion, motivation or reasonable expectation of success to do so due to the physical separation between the reservoir and the thruster. As a result, Tverdokhlebov does not teach, describe or suggest "heating the reservoir with the plasma," as required in amended claim 22. Furthermore, Tverdokhlebov does not teach, describe or suggest "maintaining the temperature of the propellant between $T_m$ and $T_b$ by controlling power input from the external power supply and heat input from the plasma," as claimed in amended claim 22.

Thus, Rogers and Tverdokhlebov, either alone or in combination, do not teach, describe or suggest all of the claim limitations of amended claim 22.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §103(a) rejection of claim 22.

Dependent claims 23-26 and 30

Claims 23-26 and 30 are each ultimately dependent upon amended claim 22, and are therefore allowable based upon amended claim 22, and upon other features and elements claimed in claims 23-26 and 30 but not discussed herein.

Accordingly, and for other reasons not discussed herein, the Applicant respectfully requests withdrawal of the 35 U.S.C. §103(a) rejection of claims 23-26 and 30.

ALLOWABLE SUBJECT MATTER

The Applicant gratefully acknowledges the Examiner's indication that Claims 10-13 and 27-29 contain allowable subject matter and the Examiner's allowance of Claims 14-21.

CONCLUSION

In view of the amendments and remarks presented herein, the Applicant respectfully submits that the claims as amended are in condition for allowance. The Applicant requests that the Examiner telephone the attorney of record in the event a telephone discussion would be helpful in advancing the prosecution of the present application.

Respectfully submitted,

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